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FOR

APPARATUS AND METHOD FOR ADAPTIVELY MODULATING SIGNAL BY USING
LAYERED TIME-SPACE DETECTOR USED IN MIMO SYSTEM

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APPARATUS AND METHOD FOR ADAPTIVELY MODULATING SIGNAL BY USING LAYERED TIME-SPACE DETECTOR USED IN MIMO SYSTEM

Field of the Invention

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The present invention relates to an apparatus for modulating/demodulating signal by using a layered time-space architecture detector in a multi-input multi-output (MIMO) system and a method thereof; and, more particularly, 10 to the apparatus for modulating/demodulating signal by using a layered time-space architecture detector in a multi-input multi-output (MIMO) system in order to increase a system performance by deciding an equivalent channel gain, deciding the number of bits for transmitting through each 15 antenna and deciding a transmission power by using the a greedy algorithm based on the decided equivalent channel gain.

Description of Related Arts

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Generally, a multi-input multi-output (MIMO) system is a wireless communication system obtaining high frequency efficiency by transmitting each different data through a plurality of transmission antennas in an identical 25 bandwidth. There have been several detection methods for MIMO systems, such as a Diagonal Bell Laboratories Space Time (D-BLAST) system proposed in an article by G. J.

Foschini, entitled "Layered Space-Time Architecture for Wireless Communication in a Fading Environment When using Multi-Element Antennas," *Bell Labs Technical Journal*, fall, pp. 41~59, 1999 and a Vertical-Bell Laboratories Space Time

5 (V-BLAST) system introduced in an article by P.W. Wolniansky et.al., entitled "V-Blast: An Architecture for Realizing Very High Data Rates Over the Rich-Scattering Wireless Channel." *Proc. International Symposium Signals, Systems and Electronics*, September, 1998.

10   The V-BLAST system is a modified scheme of the D-BLAST system.

Operations of detection in the V-BLAST system are explained in more detail hereinafter. At first, a symbol corresponding to a layer having the largest equivalent

15 channel gain is detected based on a MIMO channel matrix and new channel matrix is built by nulling a channel corresponding to the currently detected layer after canceling the effect of the detected symbol in the channel matrix H. And the above mentioned steps are repeated until

20 all symbols are detected. As a result of these operations, a layer having largest equivalent channel gain is detected for the first time. When the next symbol is detected, the effect of the first symbol is eliminated because it is considered as interference and then the next symbol is

25 detected. Therefore, a diversity gain can be obtained when the next symbol is detected and a performance is increased.

In a meantime, a structure of V-BLAST system is in

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U.S. patent No. 6,317,466 B1 issued to G.J. Foschini, entitled "Wireless Communications System Having a Space-Time Architecture Employing Multi-Element antenna at both the Transmitter and Receiver" and also an adaptive

5 modulation method is disclosed. But in the above mentioned patent by G.J. Foschini, a method for minimizing transmission power and changing modulation method commonly used for all antennas.

Furthermore, a greedy algorithm for allocating power
10 and the number of bits in multicarrier systems is introduced in an article by C. Y. Wong, entitled "Multi-user OFDM with adaptive sub-carrier, bit and power allocation", *IEEE Journal on Selected Areas in Communication*, Vol. 17, pp. 1747~1758, Oct., 1999. The
15 greedy algorithm is used for calculating a power and the number of bits of each subcarrier in order to transmit all information bits with the minimum transmission power while satisfying desired bit error rate under conditions such as single user orthogonal frequency division multiplexing
20 (OFDM) is used, a frequency domain channel response corresponding to each subcarrier is known at the transmitter, the number of bits for transmitting at one OFDM symbol is predetermined and there is a desired bit error rate.

25 There are two methods implementing the MIMO-OFDM system with the adaptive modulation method. A first method is introduced in an article by Ka-Wai Ng. et. al., entitled

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"A simplified bit allocation for V-BLAST based OFDM MIMO system in frequency selective fading channels" *IEEE international conference on communication*, pp. 411~415, 2002. A second method is disclosed in an article by Ka-wai

5　Ng et. al., entitled "Iterative bit & power allocation for V-BLAST based OFDM MIMO system in frequency selective fading channel", *Proc. Wireless Communications and Networking Conference*, 2002, pp. 271~275.

The first method calculates the equivalent channel

10　gain based on an ordering method of the V-BLAST and decides the number of bits according to the greedy algorithm based on the calculated equivalent channel. It is also disclosed that a method of selecting a subcarrier and transmitting antenna in order to reduce the amount of information

15　transmitted to the transmitter. The above mentioned approaches using the V-BLAST ordering method may obtain nearly same performance for all layers when fixed modulation method is used. However, the performance is degraded in a case of an adaptive modulation is used.

20　The second method allocates a predetermined number of bits to all possible combinations of decision order for the optimal solution and selects the optimal order with minimum total transmission power. However, by reducing the number of combinations to be considered for finding the optimal

25　solution, the performance is degraded.

Summary of the Invention

It is, therefore, an object of the present invention to provide an apparatus for adaptively modulating /demodulating signal by using a layered time-space architecture detector in a multi-input multi-output (MIMO) system for improving a system performance by deciding an equivalent channel gain, deciding the number of bits for transmitting through each antenna and a transmission power by using a greedy algorithm based on the decided equivalent channel gain.

In accordance with an aspect of the present invention, there is provided an apparatus for adaptively modulating signal in a MIMO system having a layered space-time architecture based detector, the apparatus including: a bit and power allocation information calculator for deciding an equivalent channel gain in a reverse order of Vertical-Bell laboratories Space Time (V-BLAST) based on MIMO channel information feedbacked from a receiver and determining the number of bits and transmission power to be transmitted from each transmitting antenna by using the equivalent channel gain; and adaptive modulation means for modulating signal of each layer with corresponding modulation method based on the determined number of bits and transmitting power.

In accordance with an aspect of the present invention, there is provided an apparatus for adaptively demodulating

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signal in a MIMO system having a layered space-time architecture based detector, the apparatus including: MIMO channel estimation unit for estimating MIMO channel from a signal received through each receiving antenna; a bit and power allocation information calculator for determining an equivalent channel gain in reverse order of Vertical-Bell laboratories Space Time V-BLAST based on MIMO channel information from the MIMO channel estimation unit and determining the number of bits corresponding to each transmitting antenna by using the equivalent channel gain.

In accordance with an aspect of the present invention, there is provided apparatus for adaptively modulating and demodulating signals in MIMO system using multiple antennas at transmitter and receiver, the apparatus including: an adaptive modulation unit for adaptively modulating signals in order to transmit the modulated signal after determining an equivalent channel gain in a reverse order of a vertical-bell laboratories space time and determining the number of bits and transmitting power based on the determined equivalent channel gain; and adaptive demodulation unit for detecting and adaptively demodulating received signals through each receiving antenna in reverse order of V-BLAST.

In accordance with an aspect of the present invention, there is provided a method for adaptively modulating signals in a MIMO system using multiple antennas in a receiver and transmitter, the method, including the steps

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of: a) determining equivalent channel gain in a reverse order of V-BLAST at transmitter based on channel information feed backed from the receivers; and b) adaptively modulating signals by determining the number of

5   bits and corresponding transmitting power to be transmitted through each layer (antenna) by using the equivalent channel gain in a greedy algorithm.

In accordance with an aspect of the present invention, there is provided a method for adaptively demodulating in

10   MIMO systems, the method including the steps of: a) estimating a channel from a signal received at each receiving antenna; b) deciding an equivalent channel gain in a reverse order of a vertical-bell laboratories space time (V-BLAST) based on the channel information; and c)

15   detecting and adaptively demodulating the received signal using the adaptive modulation information for each layer.

In accordance with an aspect of the present invention, there is provided a computer readable recoding medium storing instructions for executing a method for an adaptive

20   modulation, the method including the steps of: a) at a transmitter, deciding an equivalent channel gain in a reverse order of V-BLAST based on a feedback information from a receiver; and b) at the transmitter, deciding the number of bit transmitting through each layer (transmitting

25   antenna) and transmitting power based on the equivalent channel gain computed at the step a).

In accordance with an aspect of the present invention,

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there is provided a computer readable recoding medium storing instructions for executing a method for an adaptive demodulation, the method including the steps of: a) estimating a channel from a signal received from each

5   receiving antenna; b) deciding an equivalent channel gain in a reverse order of V-BLAST based on the channel information; and c) detecting and adaptively demodulating by deciding the number bits for each layer.

10   Brief Description of the Drawing(s)

The above and other objects and features of the present invention will become apparent from the following description of the preferred embodiments given in

15   conjunction with the accompanying drawings, in which:

Fig. 1 is a diagram for illustrating a MIMO wireless communication system having a layered space-time architecture detector in accordance with a preferred embodiment of the present invention;

20   Fig. 2 is a view showing changing of equivalent channel gain according to the detection order in layered space-time architecture in accordance with the present invention;

Fig. 3 is a flowchart for explaining a method for

25   determining the equivalent channel gain in a reverse order of the V-BLAST detection method;

Fig. 4 is a flowchart for explaining steps for

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determining the number of bits for transmitting of each transmitting antenna and corresponding transmitting power by using a equivalent channel gain according to greedy algorithm in accordance with a preferred embodiment;

5   Fig. 5 is a diagram showing an apparatus for adaptively modulating/demodulating signal in the MIMO wireless communication system having layered space-time architecture in accordance with a preferred embodiment of the present invention;

10   Fig. 6 is a graph showing a performance of a method for adaptively modulating/demodulating signals in a MIMO wireless communication system having V-BLAST type detector in accordance with a preferred embodiment of the present invention;

15   Fig. 7 is a diagram showing an apparatus for adaptively modulating/demodulating signals in MIMO OFDM wireless communication system having V-BLAST type detector in accordance with a preferred embodiment of the present invention; and

20   Fig. 8 is a graph showing a result of a simulation of a method for adaptively modulating/demodulating signal in MIMO OFDM wireless system having V-BLAST type detector in accordance with a preferred embodiment of the present invention.

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Detailed Description of the Invention

Other objects and aspects of the invention will become apparent from the following description of the embodiments with reference to the accompanying drawings, which is set forth hereinafter.

5   For helping to understand the present invention, a greedy algorithm used in an adaptive modulation/demodulation method in accordance with the present invention is explained at first.

For explaining the greedy algorithm, an orthogonal
10   frequency division multiplexing method is used as an example.

At first, the transmission power of the nth subcarrier of , P_n, is given as:

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$$P_n = \frac{f(C_n)}{|h_n|^2} \qquad\qquad Eq.\ 1$$

In the Eq. 1, h_n is a channel gain of the nth subcarrier, C_n is the number of bit for transmitting with the subcarrier, and $f(C_n)$ is a is a transmission power for
20   transmitting c bits with desired bit error rate (BER).

In a meantime, if an entire bits for transmitting one of OFDM symbol is R, a bit allocation method for minimizing a sum of transmission power of entire subcarrier can be expressed as:

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$$P_t = \min_{c_x \in D} \sum_{n=1}^{N_c} \frac{1}{|h_n|^2} f(C_n) \qquad\qquad \text{Eq. 2}$$

$$\text{subject to } R = \sum_{n=1}^{N_c} c_n$$

In the Eq. 2, Nc is the number of total subcarriers, D represents a set of information bits per subcarrier determined by modulation/demodulation methods. For example, if a QPSK, 16-QAM, 64-QAM and so on can be selected for the modulation/demodulation methods, then D = {0, 2, 4, 6, 8, …}. In here, 0 means that no information is sent in the corresponding subcarrier.

The Eq. 2 can be solved by the greedy algorithm through following steps.

step 1: For all subcarriers, we define c_n=0, $\Delta P_n = \dfrac{f(\Delta B)}{|h_n|^2}$.

step 2: following equations 3, 4 and 5 are repeatedly operated until the condition $R = \sum_{n=1}^{N_c} c_n$ is satified.

$$\hat{n} = \arg\min_n P_n \qquad\qquad \text{Eq. 3}$$

$$C_n = C_n + \Delta B \qquad\qquad \text{Eq. 4}$$

$$\Delta P_n = \frac{f(C_n + \Delta B) - f(C_n)}{|h_n|^2} \qquad\qquad \text{Eq. 5}$$

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In the Eqs. 4 and 5, ΔB is the difference of elements of set D e.g., D={0, 2, 4, 6, …}. Therefore, ΔB =2.

step 3: after completing step 2, each C_n is determined and P_n is calculated by using eq. 1.

Finally, the number of bits allocated to each subcarrier, C_n, and the transmission power, P_n, is determined.

In the V-BLAST detection method, data transmitted from a plurality of transmitting antenna is detected as one by one and the detected symbols are cancelled for reducing interference to other signals. The next symbol is detected after canceling the channel effect corresponding to the previously detected symbol. Therefore, the equivalent channel gain is varied according to an order of nulling. The present invention provides a method for achieving performance gain by adaptively modulating the signal with an equivalent channel gain obtained by the reverse order of conventional V-BLAST detection order. Hereinafter, the V-BLAST detection method is explained at first.

Fig. 1 is diagram for illustrating a MIMO wireless communication system having a layered space-time architecture detector in accordance with a preferred embodiment of the present invention.

Referring to Fig. 1, in the MIMO wireless communication system having a detector of V-BLAST structure, a signal vector transmitted from each transmission antenna 13-1, 13-2, …, 13-M is defined as $\mathbf{x}=[x_0, \ x_1, \ …, \ x_{M-1}]^T$ and a

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signal vector received to each receiving antenna 15-1, 15-2, ..., 15-N is defined as $\mathbf{y}=[y_0, y_1, ..., y_{N-1}]^T$. M and N is the number of transmitting/receiving antennas and it is satisfied with a condition, N ≥ M. The received signal vector is expressed as:

$$\mathbf{y} = \mathbf{Hx} + \mathbf{v} \qquad\qquad \text{Eq. 6}$$

In the Eq. 6, $\mathbf{H}$ is N × M channel matrix, the element of the nth row and, a mth column, $h_{n,m}$, is a flat fading channel gain between m^{th} transmitting antenna and n^{th} receiving antenna. In a meantime, v is a N×1 white noise vector with zero mean and its covariance matrix is $E[vv^H]=\sigma^2 I$. I is N×N unit matrix.

For detection of the transmitting signal vector x from the receiving signal vector y, the V-BLAST detection method is used. A nulling vector for k^{th} layer (k^{th} transmission antenna signal) is defined as:

$$\mathbf{w}_k{}^T(\mathbf{H})_l = \delta_{kl} = \begin{cases} 1 & ,k=l \\ 0 & ,k \neq l \end{cases} \qquad\qquad \text{Eq. 7}$$

In the Eq. 7, $(H)_l$ is l^{th} column of matrix H and w_k^T is a kth column of a pseudo-inverse matrix H^+. A detection order is determined by considering a value of w_k. In the conventional V-BLAST detection, a column of the matrix

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having smallest value of $\|w_k\|$ is detected at first. In a meantime, Z_k is a decision statistic of kth layer and it is expressed as:

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$$Z_k = x_k + w_k^T v \qquad\qquad\text{Eq. 8}$$

In the Eq. 8, k = {1, 2, …, M}. After determining the signal by considering the decision statistic Z_k , an interference of the previous detected signal is cancelled

10   and the channel matrix H is updated. That is, new channel matrix H is generated by setting k^{th} column of prior matrix H as '0'. New received signal vector y' is determined as:

$$y' = y - (H)_k x_k \qquad\qquad\text{Eq. 9}$$

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In the Eq. 9, x_k is a result of decision of Z_k. The Eqs. 6 to 9 are repeatedly executed for calculating a nulling vector by using new channel matrix H' and receiving signal vector y' until all signals are detected. The above

20   mentioned steps are detection steps of conventional V-BLAST. Order of detection is determined according to the magnitude of norm of nulling vector.

If the eq. 7 is used for calculating a signal – to – noise ratio of the decision statistics, ρ_k , which is

25   calculated as:

$$\rho_k = \frac{E\{|x_k|^2\}}{\sigma^2\|\mathbf{w_k}\|^2} \qquad\qquad \text{Eq. 10}$$

In the Eq. 10, E{} is an expectation function and $\|w_k\|^2$ is the equivalent channel gain. Therefore, a state of

5 channel is better as $\|w_k\|$ is getting smaller. The V-BLAST method for MIMO system using a fixed modulation/demodulation method detects a layer of best channel state at first and then detects a layer of worse channel state after eliminating interference of signals,

10 which have already been detected in order to enhance performance of all layers.

However, the adaptive modulation/demodulation method detects a layer of best channel state later and information of a layer of worse channel is not transmitted or less

15 amount of information is transmitted in order to enhance the performance. Therefore, the detection order must to be reversed for enhancing the performance in accordance with the present invention.

Fig. 5 is a diagram showing an adaptive

20 modulation/demodulation, and in the MIMO wireless communication system with V-BLAST type in accordance with a preferred embodiment of the present invention.

Referring to Fig. 5, a MIMO system having V-BLAST detector includes an adaptive modulation unit 52 and an

25 adaptive demodulation unit 57 for modulating/demodulating

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signals with using different demodulation/modulation method and controlling transmission power of the signal. The demodulation unit 57 includes a V-BLAST type detection unit.

Operations of the adaptive modulation/demodulation units 52 and 57 are explained in detail as followings.

A transmitting data 51 is data transmitted from a transmitter. If necessary, this date would be scrambled, channel coded, and interleaved. The adaptive modulation unit receives the channel information and controls transmitting power by modulating the data with different modulation methods according to each layer by using bit and power allocation information.

When adaptively modulated signals are transmitted through M transmitting antennas 53-1 to 53-M, a bit and power allocation information calculator 54 determines the number of bits and transmitting power to be transmitted to each transmitting antennas 53-1 to 53-M by using MIMO channel information feedbacked from a receivers and the greedy algorithm.

Through the above mentioned operations, signals transmitted from the M transmitting antennas 53-1 to 53-M are transmitted to N receiving antennas 56-1 to 56-N through frequency non-selective fading MIMO channel. And the adaptive demodulation unit 57 demodulates the received signals by using channel estimation result from a MIMO channel estimator 58 and a bit allocate information from the bit allocation information calculator 59 in reverse

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order of V-BLAST. Finally, the demodulated signal is outputted.

Fig. 2 is a view showing changing of equivalent channel gain according to an order of nulling in a layered space-time architecture in accordance with the present invention.

Referring to Fig. 2, although identical channel matrix is used, the equivalent channel gain is changed according to an order of detection such as an order of V-BLAST, a random order and a reverse order of V-BLAST. Thus, in case of detection according to the order of V-BLAST, a deviation of the equivalent channel gain is small and the sum of equivalent channel gain is small. And in case of detecting according to the reverse order of V-BLAST, the deviation and sum of the equivalent channel gain become larger.

A method for determining the equivalent channel gain in a reverse order of the V-BLAST detection method in accordance with a preferred embodiment of the present invention is explained in detail.

Fig. 3 is a flowchart for explaining the method for determining the equivalent channel gain in a reverse order of the V-BLAST detection method.

Referring to Fig. 3, at step 31, an antenna index set is defined (S={1, 2, …, M}) because of determining an order of detection for determining the equivalent channel gain. An pseudo-inverse Matrix of channel matrix H^+ is calculated

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at step 32. At step 33, all nulling vectors w_k^T, k∈S, are calculated based on the Eq. 7 for calculating transmitting signal vector x .

After the step 33, square root of a norm of nulling vector is calculated for determining a layer for nulling and kth layer having the largest value is selected at step 34. A column of the channel matrix corresponding to the selected kth layer is transformed to 0 vector and a value k is eliminated from the set S at step 35. The above mentioned steps are repeated M times with newly transformed set S and channel matrix H.

As mentioned above, an order of the selected layers becomes a detection order and an inverse of square root norm of the nulling vector for the selected layer becomes the equivalent channel gain. Furthermore, the number of bits transmitted at each layer (transmitting antenna) and corresponding transmitting power is calculated by using the calculated equivalent channel gain instead of subcarrier channel gain $||h_n||^2$ in greedy algorithm.

Fig. 4 is a flowchart for explaining steps for determining the number of bits for transmitting of each transmitting antenna and corresponding transmitting power by using a equivalent channel gain according to greedy algorithm in accordance with a preferred embodiment of the present invention.

Referring to Fig. 4, at step 41, the number of bits transmitted at each layer (each transmitting antenna) is

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initialized as '0'. ΔB is defined based on the Eq. 2 and a transmitting power is calculated for obtaining an additional bit value of ΔB with desired bit error rate at each layer by using the equivalent channel gain of each layer. Among the calculated layers, a layer requiring the least transmitting power is selected and the value of ΔB is putted to the selected layer. The above mentioned steps are repeatedly performed until allocated total bit number is assigned. After determining the number of bits transmitted through each layer, a transmitting power of each layer is calculated based on the Eq. 1.

Fig. 6 is a graph showing a performance of an adaptive modulation/demodulation method of a MIMO wireless communication system with V-BLAST type detector in accordance with a preferred embodiment of the present invention. The graph shows result of simulation for comparing performance of a conventional modulation/demodulation method and the modulation/demodulation method in accordance with the present invention.

In the simulation, the number of transmitting and receiving antennas is 4 and a channel of each transmitting and receiving antenna is a complex Gaussian random variable with zero mean. For preventing to limit performance by influence of specific channel matrix, more than 1000 statistic channels are generated. The number of information bits for transmitting in a predetermined time is set to 8

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and QPSK and 16-QAM are used for modulation method. Thus, D={0, 2, 4} and therefore, ΔB is 2.

In the simulation, a system performance of a conventional modulation/demodulation method implemented by using greed algorithm with singular value decomposition (SVD), which is known as the optimal solution in the adaptive modulation MIMO system is used for a lower bound for comparison. The conventional modulation /demodulation method is introduced by G.G Raleigh et. al., in "spatio-temporal coding for wireless communication" at Proc. IEEE Globecom, Nov, 1996, pp. 1809-1814 and it has too complicated structure. Thus, it is impossible to be implemented to real system.

Referring to the Fig. 6, SVD is a result of the conventional modulation/demodulation method, BLAST is a result of using V-BLAST detection order introduced by Ka-wai Ng and BLAST(random order) is a result of using random detection order. BLAST(reverse) is a result of using reverse order of the V-BLAST detection order.

As shown in Fig. 6, the present invention has 0.7 bB performance gain and 1dB performance loss in comparison with Ka-wai Ng's method and the conventional modulation/demodulation method proposed by Raleigh.

Fig. 7 is a diagram showing an adaptive modulation/demodulation apparatus of MIMO OFDM wireless communication system with V-BLAST type detector in accordance with a preferred embodiment of the present

invention.

Referring to Fig. 7, an adaptive modulation MIMO system of the present invention can be expanded to the MIMO OFDM system. It is because a channel matrix H of the MIMO system can be replaced with a channel matrix in each subcarrier of MIMO-OFDM system. There are two methods implemented to the MIMO OFDM system.

A first method is a method for implementing adaptive modulation method to all layers M and all subcarriers N_c. At first, an equivalent channel gain is independently calculated according to a layer of each transmitting antenna and subcarrier. The equivalent channel gain is calculated according to the method in Fig. 4 as much as the number of layers of the transmitting antenna times the number of subcarriers. Finally, $N_c \times R$ number of information bits and transmitting power is allocated according to the greedy algorithm introduced in Fig. 4 by using the obtained $N_c \times R$ number of equivalent channel gains.

Therefore, when total data rate is determined in the MIMO-OFDM transmitter, the number of information bits and corresponding transmitting power can be determined by using the equivalent channel gain obtained by the greedy algorithm in Fig. 4 for allocating data bits to total antennas and subcarriers. Inhere, a value of M in Fig. 4 is a value of N becomes $N_c \times M$. However, the first method is very complicated to be implemented in real system because of large number of comparison and equivalent channel gain

calculation in the greedy algorithm.

A second method is a method for adaptively modulating signal per each subcarrier, independently. That is, if total data rate is predetermined in MIMO-OFDM system and the identical data bits are allocated to each sub carrier wave, the data bits must be allocated by obtaining the equivalent channel gain of each subcarrier. In this case, the number of the equivalent channel gain is M per each subcarrier. The data bits are allocated by using the greedy algorithm in Fig. 4 in M layers. Thus, Nc times of greedy algorithm are performed and the repetition number is decreased. The second method can be simply implemented comparing to the first method but its performance is decreased compared with the first method.

The bit and power allocation information calculator 73 allocates the data bits by using the channel matrix H of each subcarrier delivered by the MIMO channel estimation unit 82 and the transmission power is also allocated to each transmitting antennas 76-1 to 76-M by using the equivalent channel gain of each subcarrier.

The adaptive modulation unit based on V-BLAST type detector performs modulation operations using bits and power allocated to each transmitting antenna 76-1 to 76-M per each subcarrier.

For demodulating a received signal at the MIMO OFDM system, bits and transmitting power is known. Therefore, in the MIMO channel estimator 82 at a receiver, a channel

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matrix H of each subcarrier is estimated and performs operations for obtaining bits and power information using the greedy algorithm. The V-BLAST detection and adaptive demodulation unit 81 demodulates a signal using bit allocation information.

Fig. 8 is a graph showing a result of a simulation of an adaptive modulation/demodulation method of MIMO OFDM wireless system with V-BLAST type detector in accordance with a preferred embodiment of the present invention.

Referring to Fig. 8, the simulation is progressed by using 4 transmitting and receiving antennas, 64 subcarriers and 16 cyclic prefixes are used for OFDM modulation. An exponentially decaying quasi-static fading channel having 8 taps is used.

The method as mentioned above can be implemented as a program and can be stored in a computer readable recording medium such as CD-ROM, RAM, ROM, Floppy disk, Hard disk and optical magnetic disk.

The present invention can improve performance above 0.7 ~ 1.4dB performance gain comparing to conventional modulation method with random and V-BLAST detection orders without increase of implementation complexity.

While the present invention has been described with respect to certain preferred embodiments, it will be apparent to those skilled in the art that various changes and modifications may be made without departing from the scope of the invention as defined in the following claims.

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